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STUDENT WORKBOOK

MATERIALS QUALITY SPECIALIST COURSE

SOILS ENGINEERING I

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SOILS ENGINEERING

SOILS I

STUDENTS'S NAME: _____

TELEPHONE: 664-4974/3075

This will be a replacement of the Soils Engineering I dated February 1984; when present stock is exhausted.

TO: ALL FUTURE MATERIAL QUALITY CONTROL SPECIALISTS

THIS WORKBOOK IS INTENDED TC BE ONLY A GUIDE FOR NOTE TAKING AND SHOULD NOT BE CONSIDERED ALL INCLUSIVE OF MATERIAL TO BE COVERED IN THIS BLOCK. AMPLE SPACE HAS BEEN PROVIDED FOR THE STUDENT TO TAKE NOTES AS HE/SHE SEES FIT.

THE STUDENT IS <u>STRONGLY</u> ENCOURAGED TO STUDY THE ASSIGNED TEXT REFERENCES FOR EACH LESSON, AS OUTLINED ON THE TRAINING SCHEDULE.

AS WITH ANY MISSION, THE SUCCESS DEPENDS GREATLY UPON THE PREPARATION PRIOR TO THE TASK.

TABLE OF CONTENTS

LESSON	PAGE
BASIC SOIL PROPERTIES	1
UNIFIED SOILS CLASSIFICATION SYSTEM	7
TAKING SOIL SAMPLES	15
OBTAIN A REPRESENTATIVE SAMPLE	17
MOISTURE CONTENT	20
FIELD IDENTIFICATION OF SOILS	29
SOILS PROFILE	35
SOLUTIONS TO PRACTICAL EXERCISES	APPENDIX A

BASIC SOIL PROPERTIES

1. Need For Studying Soils Engineering:

   a. Key to ground mobility.

   b. Key to better and more economical construction.

   c. Key to quality control.

2. Development:

   a. Soil - Definition: Soil is a heterogeneous (non-uniform) accumulation of uncemented or loosely cemented mineral grains inclosing void spaces of varying sizes. These voids may contain air, water, organic matter, or different combinations of these materials in varying amounts.

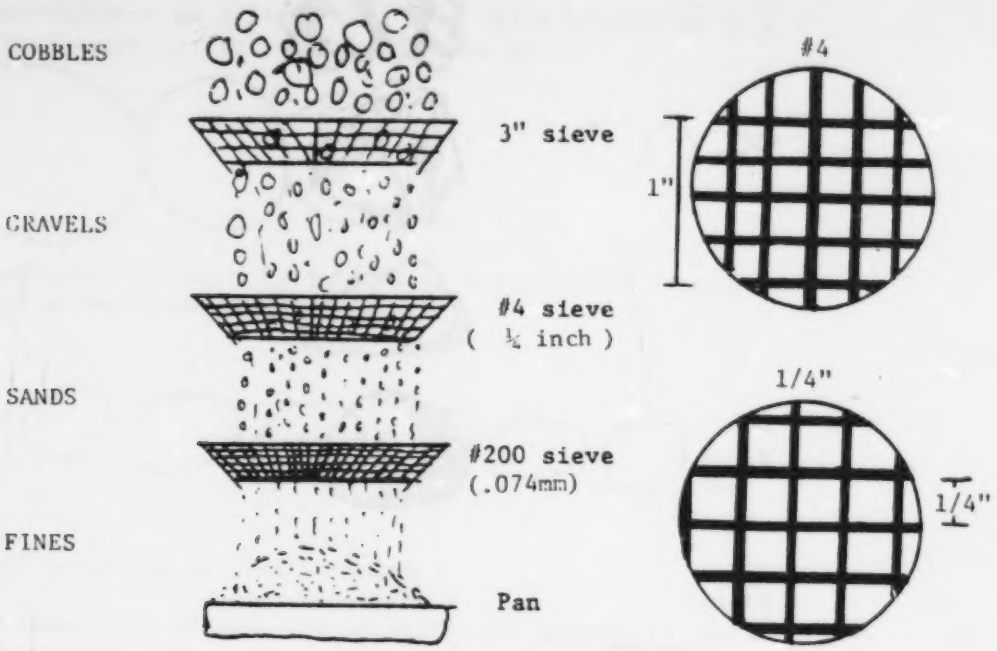
   b. Formation of Soils

      1.)

      2.)

c. Physical Characteristics of Soils

1) Size



SIZE GROUP NAMES	DEFINING SIEVE SIZES PASSING	RETAINED ON

a. Effect of Particle Size on Soil Strength.

b. Particle Size Used in Construction.

2) Shape - Bulky

a.

b.

c.

d.

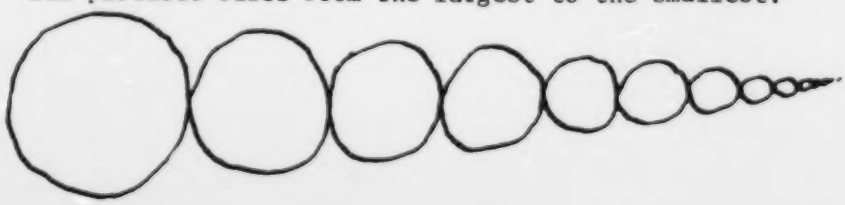
Platy

SOIL TYPE

Bulky	Platy
a.	
b.	
c.	
d.	

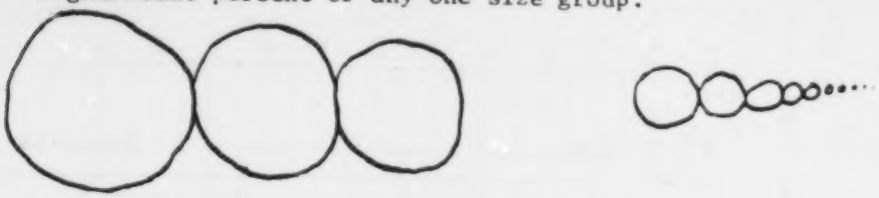
3) Gradation

a. Well-Graded - is defined as having a good representation of all particle sizes from the largest to the smallest.



b. Poorly-Graded - is defined as a soil which does not have a good representation of all particle sizes.

1) Gap-Graded - is defined as a soil which is missing a significant percent of any one size group.



2) Uniformly-Graded - is defined as a soil which is primarily all of one size group.

4) Effect of Gradation on Soil Strength

A well-graded soil is best for construction because it can be easily compacted into a dense mass with a minimum of voids.

Advantages of using a well-graded soil:

a.

b.

c.

d. Requirements for a soil to be Well-Graded

1)

2)

	GW	SW	Formula
C_u			$\frac{D_{60}}{D_{10}}$
C_c			$\frac{(D_{30})^2}{D_{60} \times D_{10}}$

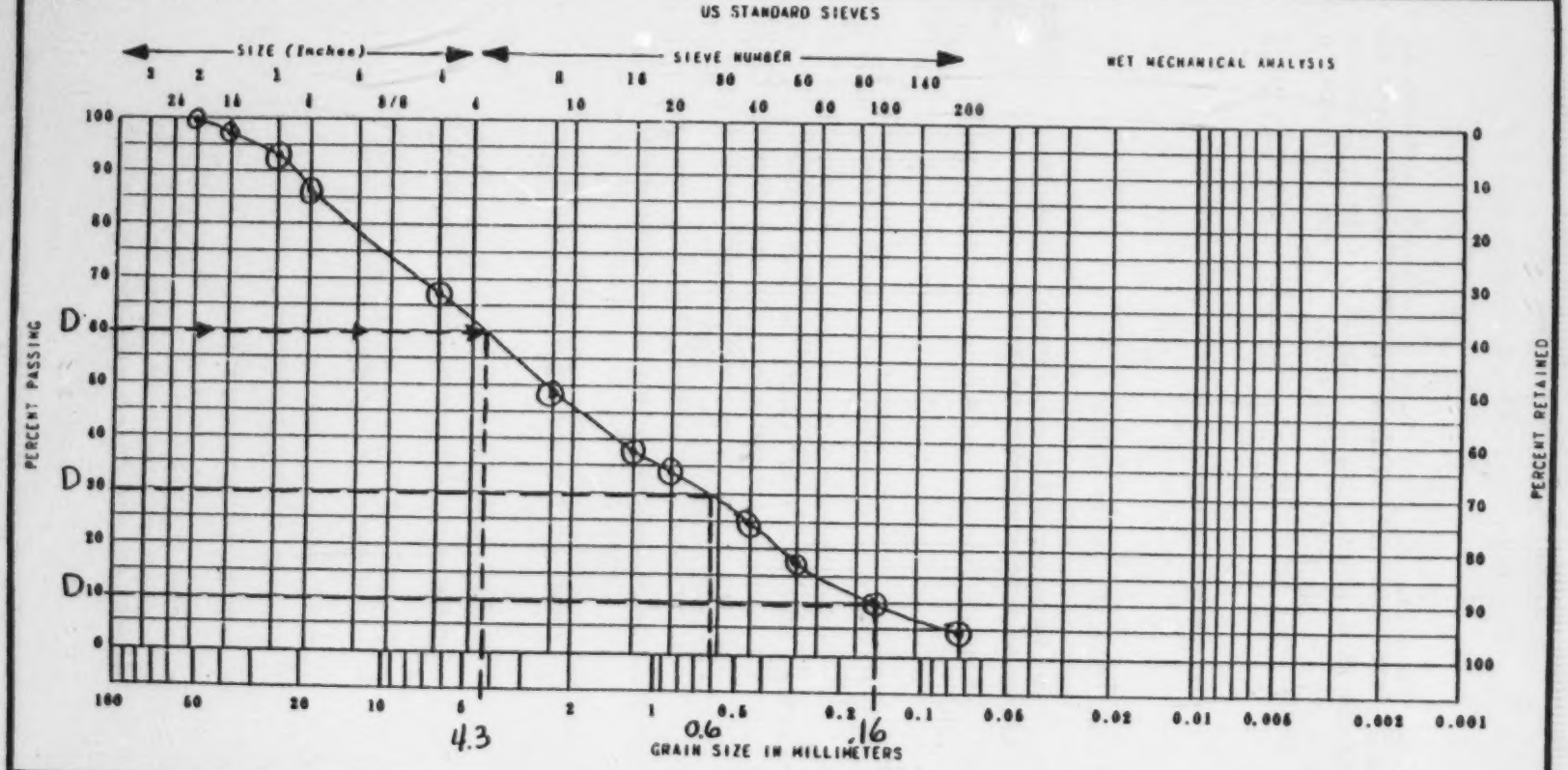
Where: GW = Gravel Well-graded
SW = Sand Well-graded
$>$ = Greater Than
$<$ = Less Than

3)

GRAIN SIZE DISTRIBUTION GRAPH - AGGREGATE GRADING CHART

DATE

PROJECT


US STANDARD SIEVES
SIZE (Inches)
SIEVE NUMBER
WET MECHANICAL ANALYSIS
3 2 1 ½ ¼ 8 16 30 50 80 140
24 16 8 3/8 4 10 20 40 60 100 200
PERCENT PASSING
PERCENT RETAINED
100 90 80 70 60 50 40 30 20 10 0
D60
D30
D10
100 50 20 10 5 2 1 0.5 0.2 0.1 0.05 0.02 0.01 0.005 0.002 0.001
4.3
0.6
.16
GRAIN SIZE IN MILLIMETERS

EXCAVATION NUMBER	SAMPLE NUMBER	NATURAL % MOISTURE	w_L	w_P	I_P	CLASSIFICATION	REMARKS
							$D_{60} = 4.3$ mm
							$D_{30} = .6$ mm
							$D_{10} = .16$ mm
TECHNICIAN (Signature)			PLOTTED BY (Signature)				CHECKED BY (Signature)

DD FORM 1 AUG 57 1207

GPO 851160

9

CLASSIFICATION OF SOILS

1. INTRODUCTION:

Selection of borrow soils and prediction of subgrade problems is vital to proper design and construction management. Classification for engineering purposes is a useful tool in providing this information, in establishing a common "language" among engineers and in checking compaction and design test results.

2. DEVELOPMENT:

a. History

b. Unified Soil Classification System

Based on those characteristics of the soil which best indicate how it will behave as a construction material.

Silts -

Clays -

c. Soil Properties as a Basis for Classification System

1)

2)

3)

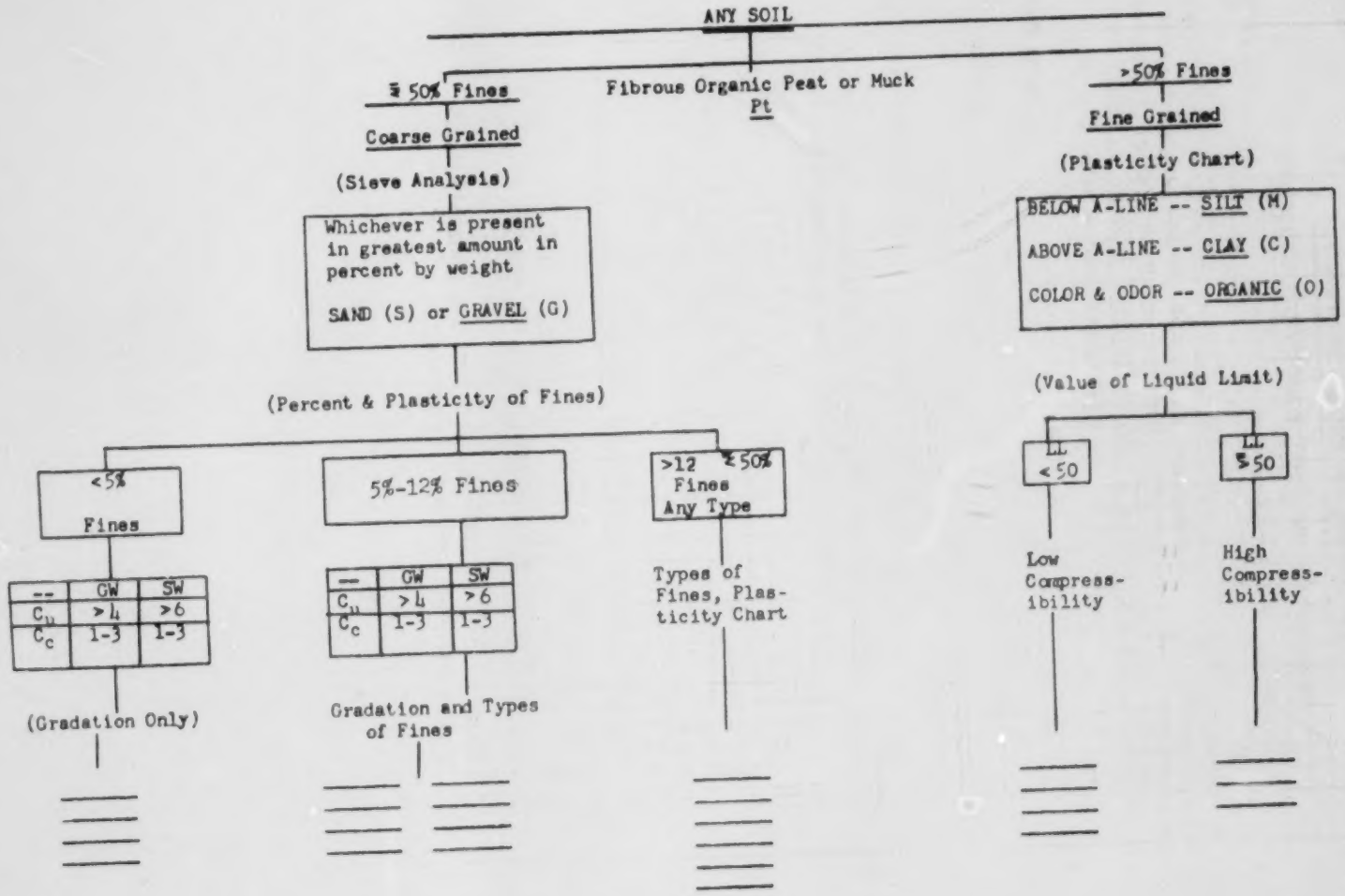
1ST LETTER (PRIMARY COMPONENT)

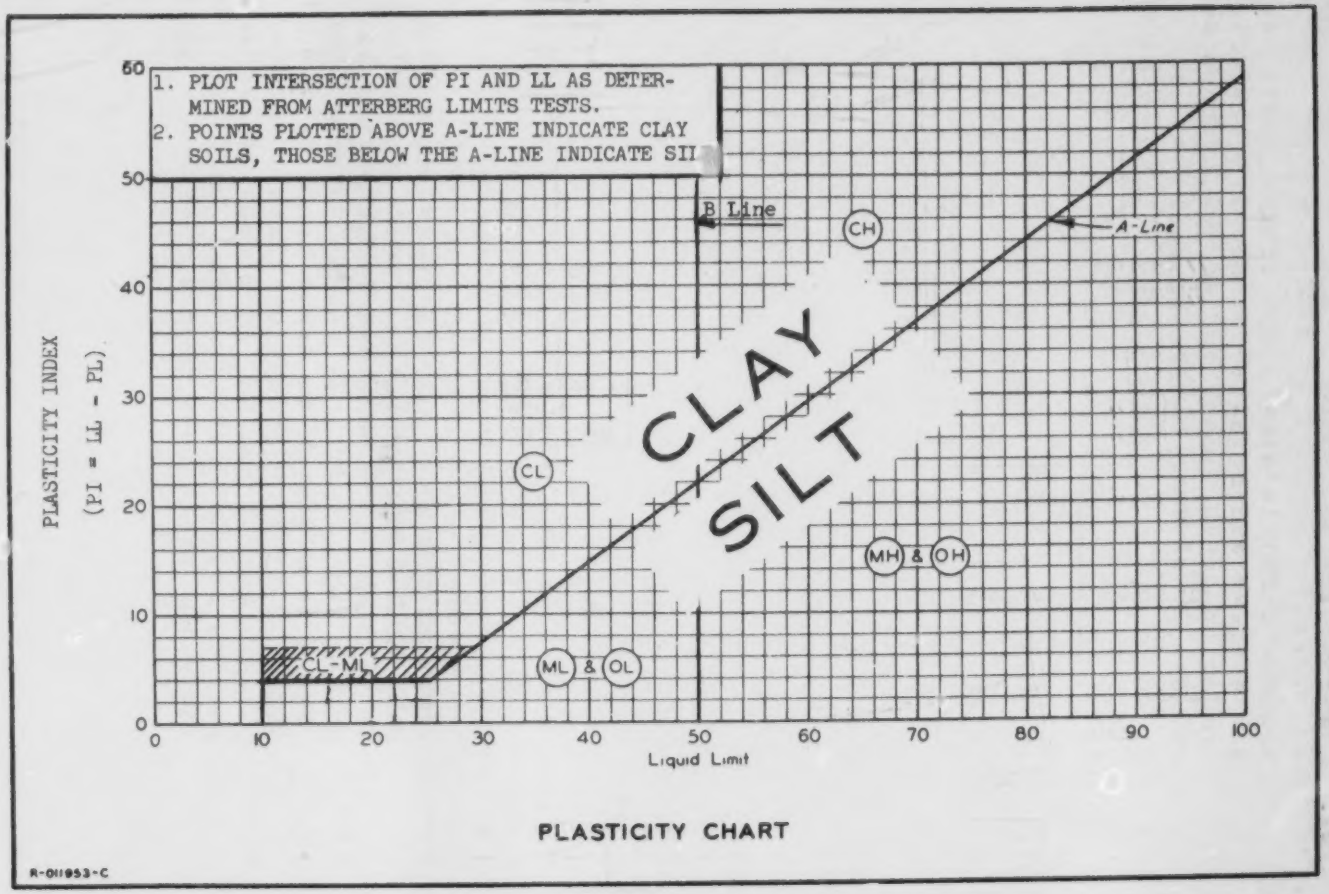
(Identifies the Predominant Soil Fraction)

2ND LETTERS (SECONDARY COMPONENT)

(An adjective further describing the characteristics of the Predominant Soil Fractions)

CLASSIFICATION PROCEDURE (Schematic)





PLASTICITY CHART

SAMPLE PROBLEM A

PROBLEM: Classify the following soil

DATA: Maximum particle size 1 1/2 inches. 42% passing No. 4 sieve and retained by No. 200. 8% fines. Gradation curve almost horizontal between No. 10 and No. 40 sieves; LL=16, PI=2

Symbol_____

SOLUTION: 42% sand and 8% fines subtracted from 100% (total sample) leave 50% gravel. Soil is coarse-grained (less than 50% fines) and first letter is G (more gravel than sand). 8% fines indicate that dual symbol is required to describe both gradation and types of fines. Gradation curve indicates material between No. 10 and No. 40 sieves is lacking, hence soil is poorly (gap) graded. The fines are silt since the PI is less than 4. Symbol: GP-GM

SAMPLE PROBLEM B

DATA: Maximum particle size 1". 90% passes the #4 sieve, 52% passes the #200 sieve. Plastic limit is 28 and the liquid limit is 40. Non-organic.

Symbol_____

SOLUTION: The 52% which passed the #200 is fines. Therefore it is a fine grained material (more than 50% fines). Subtracting the PL from the LL we have a PI of 12. When plotted this falls below the "A" line. Color and odor does not indicate an organic soil therefore it is a silt, "M". The liquid limit is less than 50 therefore it is a low compressible silt. Hence the symbol ML.

UNIFIED SOIL CLASSIFICATION SYSTEM

CLASSIFICATION PROBLEMS

Situation: The following information is available from laboratory tests on samples obtained during a soil survey for an airfield.

Required: Classify each soil using the Unified Soil Classification System, and record the group symbol in the space provided. Assume a smooth grain size distribution curve when appropriate.

Sample No.	Percentage - Dry Weight			LL	PI	Organic		Group Symbol
	Gravel	Sand	Fines			Yes	No	
1.	47.0	28.0		40	23		X	
2.	32.0 (Good representation of all particle sizes from 3/4" down) (C_c = 2.65, C_u = 34.0)		4.0	Non-Plastic			X	
3.	18.0	14.0		35	18		X	
4.	54.0 (Lacks material between 3/4" and No. 10 Sieve) (C_c = 0.65, C_u = 15.0)	38.0		Non-Plastic			X	
5.	0	24.0		55	26		X	
6.	63.0	13.0		Non-Plastic			X	
7.	25.0	37.0		45	9		X	
8.	0	18.0	82.0	80	30	X		
9.	9.0	23.0	68.0	55	32		X	
10.	61.0 (Good representation of all particle sizes from 3" down) (C_c = 1.80, C_u =47)	35.0	4.0	41	21		X	
11.	16.0	9.0	75.0	65	40		X	
12.	39.0	48.0	13.0	20	3		X	
13.	15.0	65.0	20.0	50	12		X	
14.	13.0	21.0	66.0	42	10	X		
15.	39.0	29.0	32.0	60	42		X	
16.	11.0 (74% of sample passes No. 4 sieve and is retained on No. 10 sieve) (C_c = 5.45 C_u 17)	82.0	7.0	Non-Plastic			X	

The following are a series of problems dealing with the classification of a soil. These problems are intended to improve your understanding and confidence in the soil classification procedure.

In each problem, sufficient information is provided to establish the correct Unified Soil Classification System symbol.

17. 50% Gravel, 25% Sand and _____ Fines

LL = 25 and PL = 19

Symbol_____

18. 39% Sand, 10% Gravel and _____% Fines

LL = 50 and PI = 20

Sample exhibits a musty odor and is black in color

Symbol_____

19. 27% Gravel, 19% Sand and _____% Fines

LL = 24 and PL = 19

Symbol_____

20. 42% Sand, 3% gritty fines and the Gradation curve is almost vertical.

Symbol_____

21. 42% Sand, 4% cohesionless fines, and all soil particles are apparently of a uniform size

Symbol_____

22. 39% Gravel, 12% cohesive fines and the gradation curve is horizontal between the No. 40 and the 80 sieves.

Symbol_____

TAKING SOIL SAMPLES
Ref: TM5-530, Chpt 2, Section II, pgs 2-15 thru 2-29

1. INTRODUCTION:

2. SITE LAYOUT:

   a.

   b.

   c.

3. RECORDING AND NUMBERING SAMPLES:

   a.

   b.

4. BAG SAMPLES

   a.

   b.

5. MOISTURE CONTENT SAMPLES:

   a.

   b.

6. UNDISTURBED SAMPLES:

   a.

b.

1)

2)

Remember, a sucessful soils exploration can be a complete waste of time, because of improper record keeping procedures.

OBTAIN A REPRESENTATIVE SAMPLE

1. INTRODUCTION:

2. DEVELOPMENT:

a. Quality Control

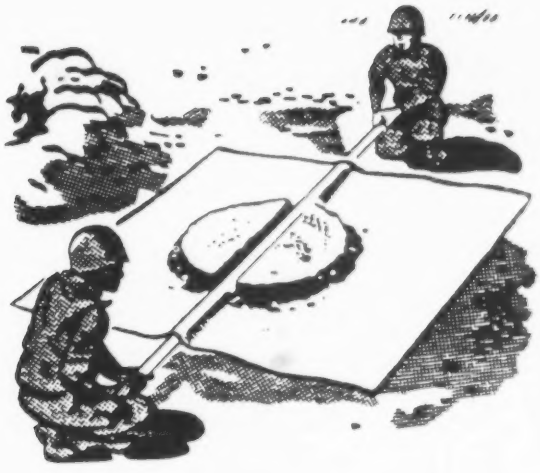
b. Quartering in the Field

(1)

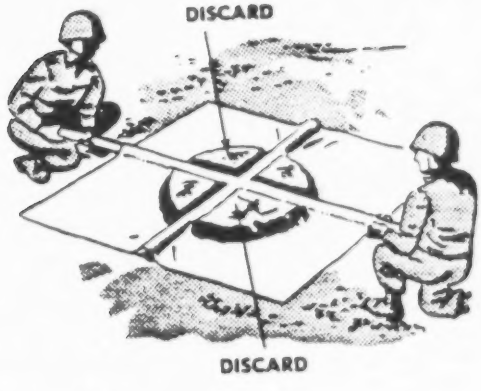
(2)

(3)

(4)

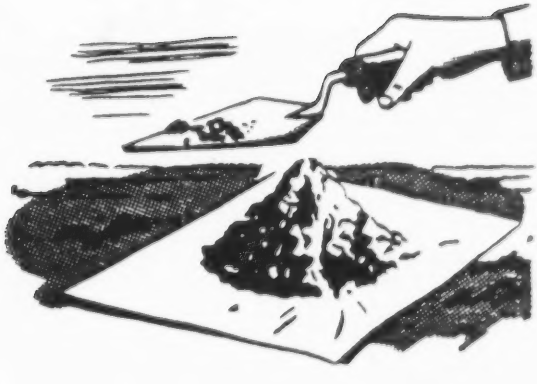


(5)



c. Quartering in the Laboratory

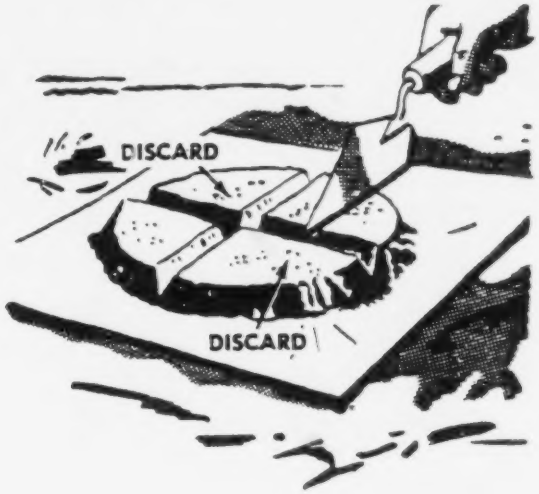
(1)



(2)

(3)

(4) Splitter



d. Laboratory Procedures

(1)

(2)

(3)

(4)

a)

b)

(5)

SOIL MOISTURE

1. Introduction:

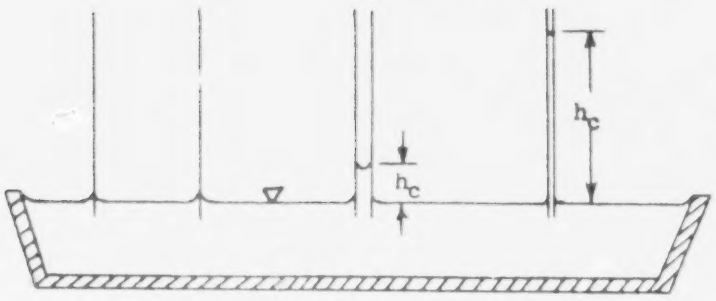
2. Sources of water:

   a. Surface water

   b. Subsurface water

      1) Gravitational water

      2) Capillary moisture

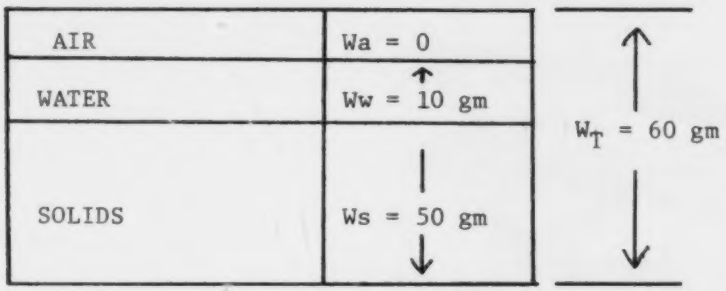


      3) Hydroscopic action

3. Effects of moisture on soils

4. Moisture content

$$\text{water content in percent} = \frac{\text{weight of water}}{\text{weight of dry solids}} \times 100$$



As an example of how this formula might be applied, suppose a sample of moist soil weighs 60 grams. If the water weighs 10 grams, the weight of the dry soil would be 50 grams. The moisture content is then obtained by dividing 10 by 50 and multiplying by 100 to convert to percent. It is equal to 20%.

$$w\% = \frac{10 \text{ gm}}{50 \text{ gm}} \times 100 = 20\%$$

5. Moisture content tests

a. Oven dried

1) Laboratory procedure (Ref TM 5-530)

a) Record identifying information of the sample on the data sheet, DD Form 1205.

b) Weigh and record the weights of the containers to be used in the test.

c) Place the sample in a container, weigh it, and record the total weight of container (tare) and wet soil. If the weight of the sample is less than 100 gm, weigh to the nearest .1 gm, otherwise the weight should be to the nearest 1.0 gm.

d) Place the open container and sample in an oven heated to 110° $\pm$ 5° C and dry until the sample weight becomes constant. This will generally require 8 to 12 hours.

e) Remove the container from the oven and replace lid, allow the sample to cool to room temperature in the open air.

f) After the sample has cooled, weigh it and the container and record the weight (tare + dry soil) on the data sheet.

2) Computations

a) Weight of water = item "A" (weight of wet soil + tare) minus item "B" (wet of dry soil + tare).

b) Weight of dry soil = item "B" (weight of dry soil + tare) minus item "D" (weight of tare).

c) Moisture content in percent= $\frac{\text{weight of water Ww}}{\text{weight of dry soil Ws}} \times 100$

b. Field Expedient Methods

1) Alcohol Burnoff Procedures

a) Record identifying information of the sample on the data sheet, DD Form 1205.

b) Weigh and record the weights of the containers to be used in the test.

c) Place the sample in the container, weigh it and record the total weight of tare and wet soil. If the weight of the sample is less than 100 grams weigh to the nearest 0.1 gram, over 100 grams weigh to the nearest 1.0 gram.

d) Saturate the sample with Methyl alcohol and ignite. When all the alcohol has burned off, stir soil and saturate again, repeat this burning process a minimum of three times.

e) Let sample cool to room temperature with lid on container.

f) After the sample has cooled, weigh sample and tare record under tare and dry soil on the data sheet.

g) Computations - Water content is computed the same was as the oven-dry method;

$$\frac{\text{Weight of water}}{\text{Weight of dry soil}} \times 100 = \% \text{ Moisture.}$$

c. "SPEEDY" Moisture Tester

SAFETY GUIDE: PLEASE REFER TO INSTRUCTIONS POSTED ON THE LID OF CONTAINER, BEFORE USING THE "SPEEDY" TESTER.

SPEEDY Reagent is a particular grade of calcium carbide which when in contact with water produces a flammable gas, Acetylene.

DO NOT operate SPEEDY in a confined space. DO NOT smoke in the vicinity of a operating SPEEDY, or operate the SPEEDY near an open flame.

1) Procedure

a) Clean the SPEEDY: Clean the inside of SPEEDY body with the supplied brush. Clean the cap and steel balls with supplied cloth. Carefully place the two steel balls into the body of the SPEEDY.

b) Prepare the Material: The SPEEDY tester is capable of determining the moisture content of many types of materials. For soils engineering, soils and aggregates will be the target of discussion.

Weigh out a 26 gram sample of material (on enclosed scale), place soil carefully into the cap of tester. Measure out three level scoops of reagent, with supplied scoop, place them into the body of the tester.

c) Testing: Test procedures are the same for all materials; however, some soils such as sands and fine-grained soils do not need the pulverizing steel balls during testing. For clays, and coarse-grained materials the pulverizing steel balls are used during testing to break up the soil.

Hold the SPEEDY horizontal to prevent mixing of the soil and reagent before the instrument is sealed. Place cap into position. Bring stirrup screw around and tighten onto the cap. Tilt tester vertically to allow soil & reagent to mix. Return to horizontal position and rotate rapidly to "place balls into orbit" for 10 seconds, stop for 20 seconds and observe tester gage at an eye level position. Repeat this process until a maximum reading has been obtained or until 3 minutes have elasped. Record reading from gage, this reading will be used later to determine comparable oven-dry percentages. The calibration curves and conversion chart will be discussed under paragraph 2, Interpolation.

d) Clean up: Carefully release pressure from the cylinder by holding the cup end away from your face and slowly unscrew the stirrup screw.

Dispose of used reagent into prescribed waste container and clean the SPEEDY as described in paragraph a) above.

2. Interpolation

a) The calibration curves, Figure MC-1, Moisture Content Determination by the Calcium Carbide Gas Pressure Method are used for materials that need the pulverizing steel balls. Using the highest reading obtained during test (Direct Reading) read over to the curve then down to Oven-dry Moisture Percentage. The curve to be used will depend on test time.

b) The conversion chart, Figure MC-2, is used to determine oven-dry moisture contents of materials that do not need the steel balls. If direct readings are not on conversion chart, you must interpolate the difference between the two known direct readings.

Example: A SPEEDY test is performed on a sand, the highest reading obtained was 3.5 (% wet weight). The difference between 3.0%, which has a known dry weight of 3.2 %, and 4.0%, which has a known dry weight of 4.3%, must be interpolated for 3.5%.

The following values are known;

% Wet Weight	% Dry Weight
3.0%	3.2%
3.5%	X
4.0%	4.3%

To find the value of X place the differences in the following steps into a ratio; i.e.

step #1	3.0%	3.2%	step # 3
step # 2	3.5%	X	
	4.0%	4.3%	step # 4

Differences -

$$\frac{\text{step \#1} - 0.5}{\text{step \#2} - 1.0} : \frac{\text{step \#3} - X}{\text{step \#4} - 1.1}$$

$$\frac{0.5}{1.0} : \frac{X}{1.1}$$ Cross multiplied X= 0.55

3.5% wet weight = 3.2% + 0.55% = 3.75% Comparable Oven-dry.

THE ALPHA-LUX COMPANY, INC.

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60 East 42nd Street
New York 17, N. Y.

MEMBER

Trenton Avenue & Somerset Street
Philadelphia 34, Pa.

SPEEDY MOISTURE TESTER CONVERSION CHART

SPEEDY READING Wet Weight	Dry Weight	SPEEDY READING Wet Weight	Dry Weight	SPEEDY READING Wet Weight	Dry Weight
1.0%	1.0%	20.5%	25.8%	33.5%	55.0%
2.0%	2.1%	21.0%	26.5%	34.0%	56.2%
3.0%	3.2%	21.5%	27.4%	34.5%	57.4%
4.0%	4.3%	22.0%	28.2%	35.0%	58.7%
5.0%	5.4%	22.5%	29.0%	35.5%	60.0%
6.0%	6.5%	23.0%	29.8%	36.0%	61.2%
7.0%	7.6%	23.5%	30.7%	36.5%	62.6%
8.0%	8.7%	24.0%	31.5%	37.0%	63.9%
9.0%	9.8%	24.5%	32.4%	37.5%	65.2%
10.0%	11.0%	25.0%	33.3%	38.0%	66.6%
10.5%	11.7%	25.5%	34.2%	38.5%	68.0%
11.0%	12.3%	26.0%	35.3%	39.0%	69.4%
11.5%	13.0%	26.5%	36.0%	39.5%	70.9%
12.0%	13.8%	27.0%	36.9%	40.0%	72.4%
12.5%	14.2%	27.5%	37.9%	40.5%	73.8%
13.0%	14.9%	28.0%	38.8%	41.0%	75.4%
13.5%	15.6%	28.5%	39.8%	41.5%	76.9%
14.0%	16.3%	29.0%	40.8%	42.0%	78.5%
14.5%	16.9%	29.5%	41.8%	42.5%	80.1%
15.0%	17.6%	30.0%	42.8%	43.0%	81.8%
15.5%	18.3%	30.5%	43.9%	43.5%	83.4%
16.0%	19.0%	31.0%	44.9%	44.0%	85.1%
16.5%	19.7%	31.5%	45.9%	44.5%	86.9%
17.0%	20.4%	32.0%	47.0%	45.0%	88.6%
17.5%	21.2%	32.5%	48.1%	45.5%	90.4%
18.0%	21.9%	33.0%	49.2%	46.0%	92.3%
18.5%	22.7%	33.5%	50.3%	46.5%	94.1%
19.0%	23.4%	34.0%	51.5%	49.0%	96.0%
19.5%	24.2%	34.5%	52.8%	49.5%	98.0%
20.0%	25.0%	35.0%	53.8%	50.0%	100.0%

SPEEDY MOISTURE TESTERS

The ALPHA-LUX COMPANY, Inc.
TRENTON AVENUE and SOMERSET STREET
PHILADELPHIA, PENNSYLVANIA 19134

REAGENT PARTS REPAIRS

Figure MC-2

THE ALPHA-LUX COMPANY, INC.

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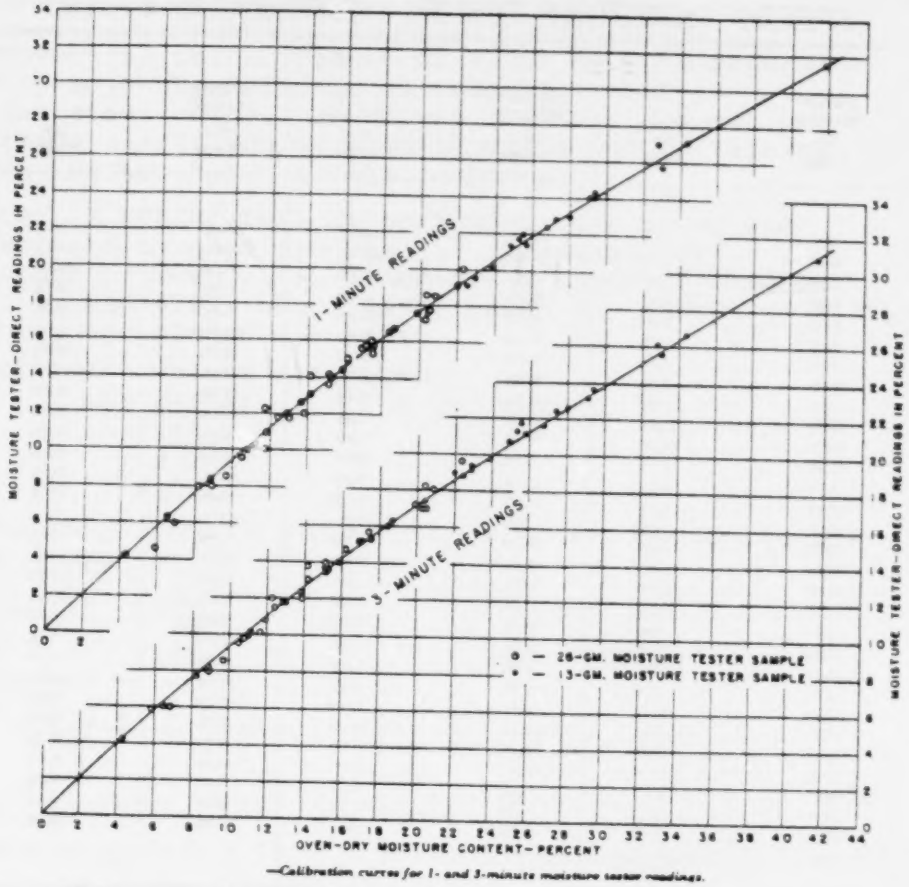

MOISTURE TESTER—DIRECT READINGS IN PERCENT
1-MINUTE READINGS
3-MINUTE READINGS
○ — 26-GM. MOISTURE TESTER SAMPLE
• — 13-GM. MOISTURE TESTER SAMPLE
OVEN-DRY MOISTURE CONTENT—PERCENT
MOISTURE TESTER—DIRECT READINGS IN PERCENT

—Calibration curves for 1- and 3-minute moisture tester readings.

Moisture Content Determination by the Calcium Carbide Gas Pressure Method

BY THE DIVISION OF PHYSICAL RESEARCH
BUREAU OF PUBLIC ROADS

Reported by JEROME R. SLYSTONE, ADRIAN PELLNER, and GEORGE P. STEPPENS, Highway Research Engineers

Figure MC-1

SOIL MOISTURE CONTENT

DATE: 26 Mar 81

PROJECT: V/STOL AIRFIELD

EXCAVATION NUMBER: (Bore Samples)

SAMPLE NUMBER: 1-1, 1-2, 2-1, 2-2, 3-1, 3-2

FORMULA: Water Content, $w = \frac{W_w}{W_s} \times 100$

TEST						
RUN NUMBER	1-1	1-2	2-1	2-2	3-1	3-2
TARE NUMBER	1-1	1-2	2-1	2-2	3-1	3-2
A. WEIGHT OF TARE + WET SOIL	18.70	19.20	44.30	47.80	26.20	53.30
B. WEIGHT OF TARE + DRY SOIL	18.63	19.12	41.97	44.46	25.03	48.71
C. WEIGHT OF WATER, W_w (A. - B.)						
D. WEIGHT OF TARE	15.67	16.14	16.09	18.45	15.81	15.95
E. WEIGHT OF DRY SOIL, W_s (B. - D.)						
WATER CONTENT, w	%	%	%	%	%	%
TEST						
RUN NUMBER	4-1	4-2				
TARE NUMBER	4-1	4-2				
A. WEIGHT OF TARE + WET SOIL	98.60	99.30				
B. WEIGHT OF TARE + DRY SOIL	91.70	91.70				
C. WEIGHT OF WATER, W_w (A. - B.)						
D. WEIGHT OF TARE	51.20	47.20				
E. WEIGHT OF DRY SOIL, W_s (B. - D.)						
WATER CONTENT, w	%	%	%	%	%	%
TEST						
RUN NUMBER						
TARE NUMBER						
A. WEIGHT OF TARE + WET SOIL						
B. WEIGHT OF TARE + DRY SOIL						
C. WEIGHT OF WATER, W_w (A. - B.)						
D. WEIGHT OF TARE						
E. WEIGHT OF DRY SOIL, W_s (B. - D.)						
WATER CONTENT, w	%	%	%	%	%	%
TEST						
RUN NUMBER						
TARE NUMBER						
A. WEIGHT OF TARE + WET SOIL						
B. WEIGHT OF TARE + DRY SOIL						
C. WEIGHT OF WATER, W_w (A. - B.)						
D. WEIGHT OF TARE						
E. WEIGHT OF DRY SOIL, W_s (B. - D.)						
WATER CONTENT, w	%	%	%	%	%	%
TEST						
RUN NUMBER						
TARE NUMBER						
A. WEIGHT OF TARE + WET SOIL						
B. WEIGHT OF TARE + DRY SOIL						
C. WEIGHT OF WATER, W_w (A. - B.)						
D. WEIGHT OF TARE						
E. WEIGHT OF DRY SOIL, W_s (B. - D.)						
WATER CONTENT, w	%	%	%	%	%	%

REMARKS (Continue on reverse if additional space is required)

TECHNICIAN (Signature): Pfc H. Cantu

COMPUTED BY (Signature):

CHECKED BY (Signature):

DD FORM 1 FEB 62 1205 EDITION OF 1 AUG 57 IS OBSOLETE. ★U.S. G.P.O. 1972-769272/225

FIELD IDENTIFICATION OF SOILS

1. Introduction

   a. Need for Field Identification

   b. Objective

2. Development

   a. Equipment

      (1) #4, 40 and 200 sieves

      (2) Entrenching tools

      (3) Spoon

      (4) Knife

      (5) Mortar and pestle

      (6) Pan and heating element

      (7) Balance or scales

   b. Procedure

   c. Tests (SEE YELLOW CARD)

3. Coarse-grained Material (gravel or sand)

4. Fine-grained Material (clay, silt or organic) - #40 Material

   a. Odor test:

   b. Dry strength test:

   c. Powder test:

   d. Feel test:

   e. Shine test:

   f. Thread test:

   g. Ribbon test:

   h. Grit or Bite test:

   i. Wet shaking test:

   j. Hand washing test:

5. Summary

   a. Soil classification (field)

   b. Soil characteristics

   c. Experience

FIELD IDENTIFICATION OF SOILS

CLASSIFICATION PROCEDURE

----- REPRESENTATIVE SAMPLE -----

Test # 1
SEPARATE GRAVEL

Test # 2
SEDIMENT TEST

Test # 3
COMPARE GRAVEL, SAND AND FINES

Test # 4
ODOR TEST, If Positive - O

DEPENDING ON THE PERCENT OF FINES

(< 5% Fines)	(> 5% < 50% Fines)	(> 50% Fines)
COMPARE GRAVEL & SAND, Whichever is greater.	COMPARE GRAVEL & SAND	Test # 5-13 DETERMINE TYPE FINES, (-) #40
	Test # 5-13 DETERMINE TYPE OF FINES, (-) #40	

FIELD IDENTIFICATION PROBLEMS

Problem # 1

The soil has greater than 50% fines and is non-organic. It cannot be rolled into a thread 1/8" in diameter at any moisture content and gives a positive reaction to the wet shaking test. A 2 inch ribbon was obtained.

Symbol _____

Problem # 2

A soil is sieved through a # 4 sieve and approximately 30% does not pass. A sedimentation test is run on that material, which passed the # 4 sieve, 60% settled. In testing the material that goes through a # 40 you found that it shines, reacts quickly in the wet shaking test, and tastes smooth.

Symbol _____

Problem # 3

Of the total sample 45% was estimated to be gravel and by the sedimentation test 60% of the - #4 material settled to the bottom of a jar after 30 seconds settlement time. The following tests were performed on - #40 material: a pat of dry soil was found to break easily and the same pat when rubbed against a sensitive part of the body produced a harsh, irritable feeling. It was impossible to roll a sample of the soil into an 1/8" thread.

Symbol _____

Problem # 4

From comparision of Gravels, Sands, and Fines, the soil sample was found to be comprised of 10% gravel, 15% sand, and 75% fines. It was almost impossible to break a dry pat of the soil and a ribbon in excess of 10" was obtained.

Symbol _____

PROBLEM #5

Your supervisor has tasked you with a mission of determining which of two borrow sites would be best suited for use as the sub-base of a proposed road on Fort Belvoir.

BORROW SITE #1: The representative sample was 45% gravel, 95% of the sample settled out during a sedimentation test. Shine test was shiny and the wet shaking test had no reaction. A ribbon of 6" was obtained and a thread was obtained easily. The bite test was gritty.

CLASSIFICATION _____

BORROW SITE #2: Comparison test showed 40% gravel, after the sedimentation was performed 80% settled out. The sample had no odor. After air-drying a soil pattie the sample was very difficult to break, the same pat of soil would not powder easily. The result of the feel test was smooth but the bite was gritty.

CLASSIFICATION _____

Best selection for subbase _____. Why?

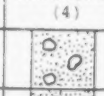
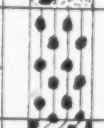
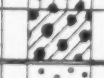
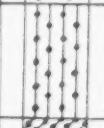
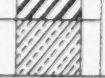
SOILS PROFILE

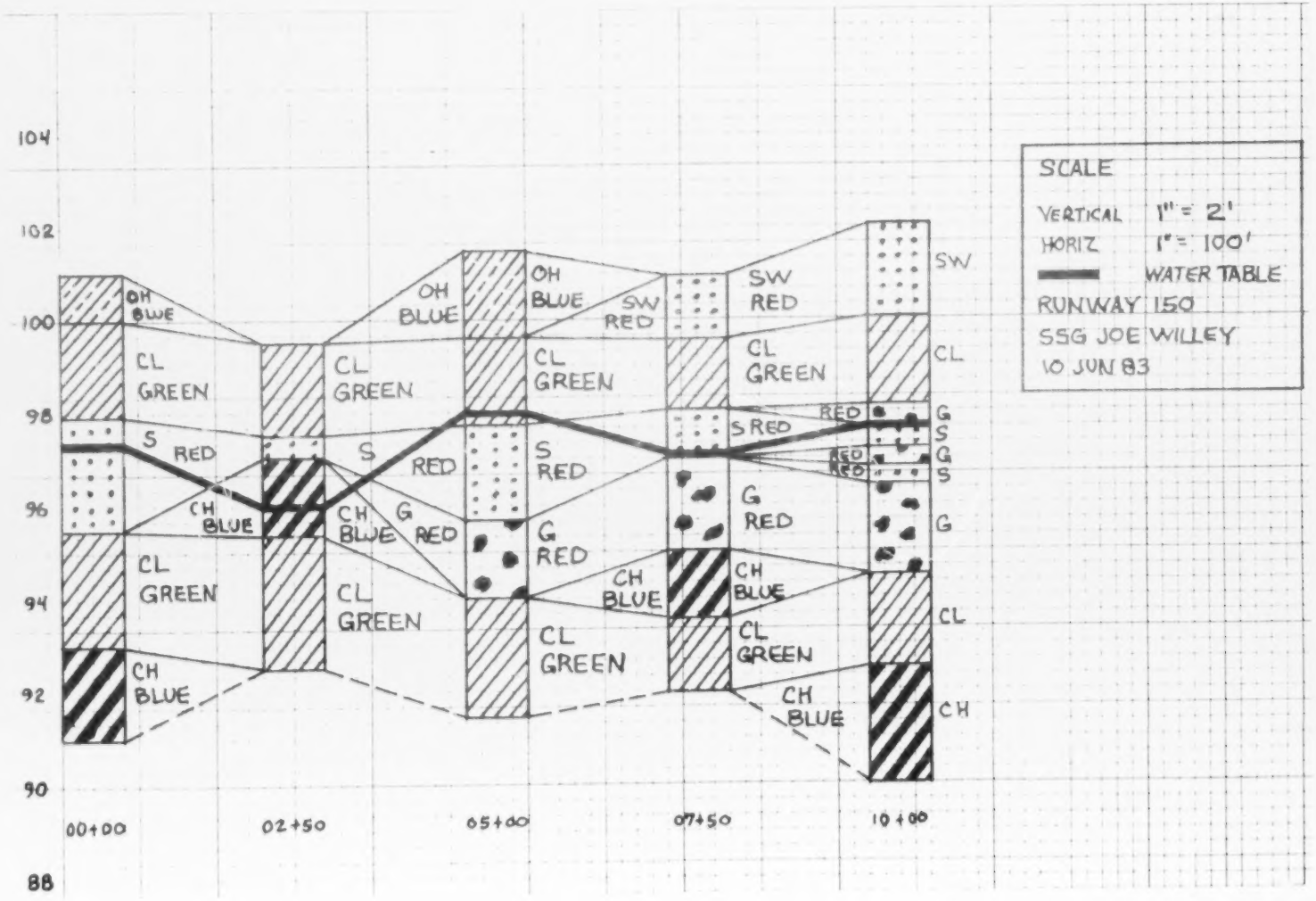
Ref: TM5-330, Chpt 2, Para 2-37, pg 2-32 & figs #2-13 + #2-14

1. DEVELOPEMENT

2. USES OF THE SOILS PROFILE:

3. STANDARD SYMBOLS:

MAJOR DIVISIONS (1)	(2)	LETTER (3)	SYMBOL HATCHING (4)	SYMBOL COLOR (5)	NAME (6)
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW		Red	Well-graded gravels or gravel-sand mixtures, little or no fines
		GP			Poorly graded gravels or gravel-sand mixtures, little or no fines
		GM d u		Yellow	Silty gravels, gravel-sand-silt mixtures
		GC			Clayey gravels, gravel-sand-clay mixtures
	SAND AND SANDY SOILS	SW		Red	Well-graded sands or gravelly sands, little or no fines
		SP			Poorly graded sands or gravelly sands, little or no fines
		SM d u		Yellow	Silty sands, silt-sand mixtures
		SC			Clayey sands, sand-clay mixtures
FINE GRAINED SOILS	SILTS AND CLAYS LL<50	ML		Green	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
		CL			Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		OL			Organic silts, and organic silt-clays of low plasticity
	SILTS AND CLAYS LL>50	MH		Blue	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic soils
		CH			Inorganic clays of high plasticity, fat clays
		OH			Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS		Pt		Orange	Peat and other highly organic soils


104
102
100
98
96
94
92
90
88
00+00
02+50
05+00
07+50
10+00
OH BLUE
CL GREEN
S RED
CH BLUE
G RED
SW RED
SW
CL
G
S
CH
SCALE
VERTICAL 1" = 2'
HORIZ 1" = 100'
WATER TABLE
RUNWAY 150
SSG JOE WILLEY
10 JUN 83

In-class
Practical Exercise

REPORT OF FOUNDATION AND BORROW INVESTIGATION

SITE Airfield Jamock TYPE EXPLORATION Hasty DATE 10 Apr 73
BORING NO. 4 LOCATION Station 20+00 GROUND ELEV. 236'
PURPOSE OF EXPLORATION Determine soil profile along the centerline of runway.

Depth Below Surface	Elev.	Sample No.	Graphic Log	Group Symbol	Description, Test Data, and Remarks
		No. 10 at ½'		OH	Brown and very plastic. Typical topsoil of the area.
1'					
		No. 11 at 2'		SM	Fine sandy soil with high percentage of silt. Light tan color.
2½'				SC	Coarse sandy soil with a plastic binder material. Light reddish color.
4½'		No. 12 at 5'		GC	Clayey gravel, high cohesion, stickey. Compact and very moist. Gravel heavily weathered and well rounded.
6½'				CH	Brown, sticky clay with very high plastic qualities. Same material as found in boring No.1 from 5ft down.
9'					Bottom of hole.

DEPTH TO WATER TABLE 3 ft

SUBMITTED BY CPL Mc Gurk

Solution to Practical Exercise in Appendix A.

REPORT OF FOUNDATION AND BORROW INVESTIGATION

SITE Airfield Jamock TYPE EXPLORATION Hasty DATE 10 Apr 73
BORING NO. 5 LOCATION Station 30+00 GROUND ELEV. 235'
PURPOSE OF EXPLORATION Determine soil profile along the Centerlin of runway

Depth Below Surface	Elev.	Sample No.	Graphic Log	Group Symbol	Description, Test Data, and Remarks
		No. 13 at ½'		OH	Dark brown and very plastic. Typical topsoil of the area.
½'		No. 14 at 2'		SM	Low cohesion fine sand with silt
2½'		No. 15 at 3½'		SC	Coarse sandy soil with a plastic binder.
4'		No. 16 at 4½'		GC	Clayey gravel sticky binder. Coarse gravel with a very sticky and wet binder material
5'				CH	Brown, sticky clay, very high plastic qualities. Easily ribbonned or rolled into thread.
8'					Bottom of hole

DEPTH TO WATER TABLE 3 ft SUBMITTED BY CPL Mc Gurk

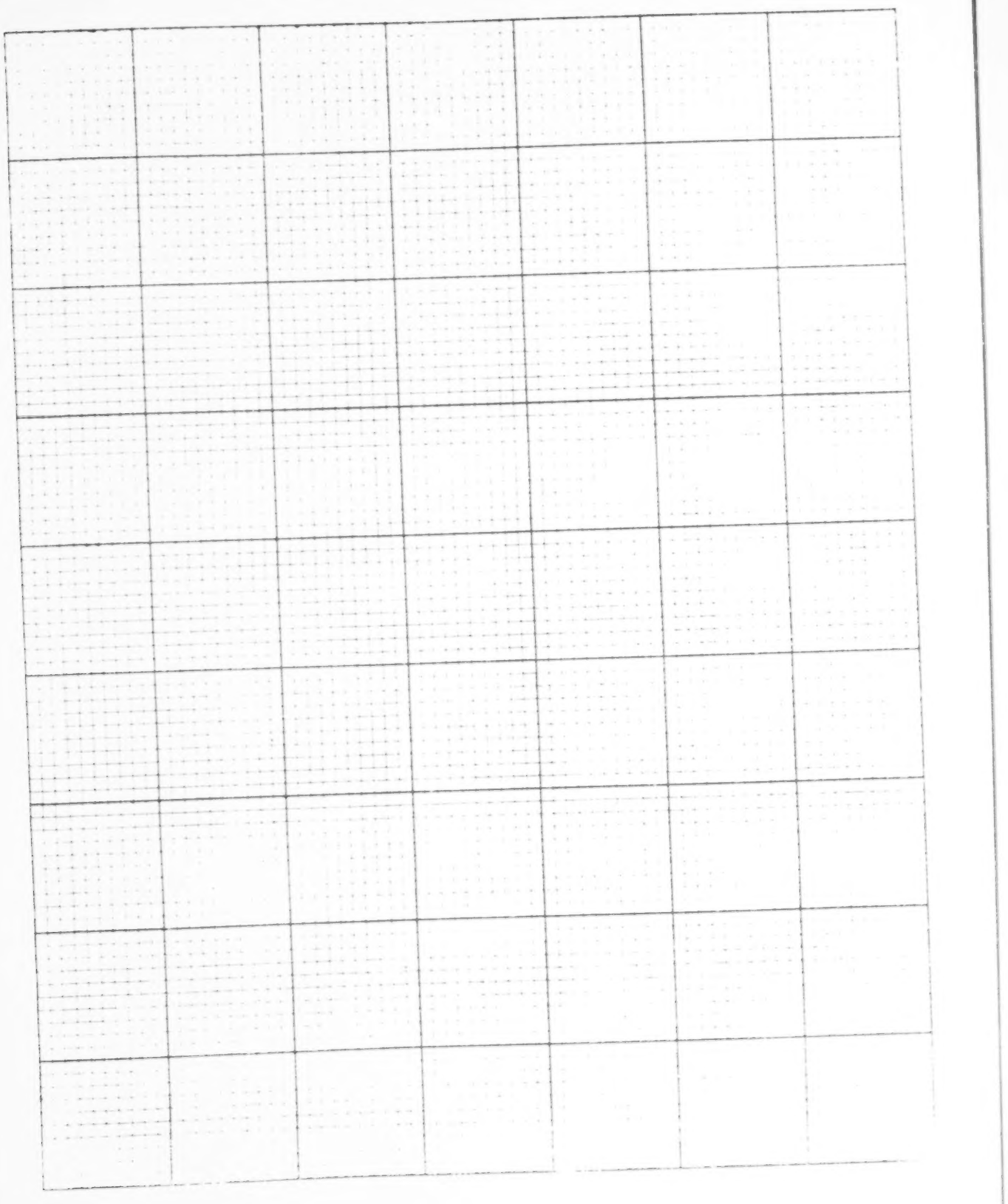
REPORT OF FOUNDATION AND BORROW INVESTIGATION

SITE Airfield Jamock TYPE EXPLORATION Hasty DATE 10 Apr 73
BORING NO. 6 LOCATION Station 40+00 GROUND ELEV. 237'
PURPOSE OF EXPLORATION Determine soil profile along the centerlin of runway.

Depth Below Surface	Elev.	Sample No.	Graphic Log	Group Symbol	Description, Test Data, and Remarks
1'		No. 17 at ½'		OH	Brown and very plastic. Typical topsoil of the area.
3'		No. 18 at 2'		SM	Fine sandy soil with high percentage of silt. Light tan color
5½'				SC	Coarse sandy soil with a plastic binder material. Light reddish color.
7'		No. 19 at 6½'		GC	Clayey gravel, high cohesion, sticky. Compact and very moist. Gravel heavily weathered and well rounded.
9½'				CH	Brown, sticky clay with very high plastic qualities. Same material as found in boring No. 1 from 5ft down.
					Bottom of hole.

DEPTH TO WATER TABLE 3 ft

SUBMITTED BY CPL Mc Gurk



SOLUTIONS

TO

PRACTICAL EXERCISES

APPENDIX A

UNIFIED SOIL CLASSIFICATION SYSTEM

#1 47% gravel, 28% sand when subtracted from the total 100% gives 25% fines. 25% fines places this soil in the range of more than 12% equal to or less than 50% fines column on the Classification Procedure Chart. Percentage of gravel gives the first letter (primary letter) of G. When plotting the LL of 40% and the PI of 23, this falls above the A-Line in the clay range. Second letter is C. Final classification symbol = GC.

#2 32% gravel, 4% fines when subtracted from the total of 100% gives 64% sand. Since the 4% fines falls within range of less than 5% fines column on the Classification Procedure Chart, the gradation of the soil is of primary importance. The predominant percentage of sand gives the first letter S. With a C_c = 2.65 and a C_u = 34.0, the sand classifies as well graded since the C_u is greater than 6 and the C_c falls between 1.0 and 3.0. Second letter is W. Final classification symbol = SW.

#3 18% gravel and 14% sand leaves a total of 68% fines. When plotting a LL of 35% and a PI of 18 on the plasticity chart it falls above the A-Line in the clay range. First letter is C. With a LL less than 50% the clay is low compressible. Second letter is L. The final classification symbol = CL.

#4 54% gravel, 38% sand leaves a total of 8% fines. Soil falls in the range between 5% and equal to or less than 12% fines column on the Classification Procedure Chart requiring a dual letter symbol. With 54% gravel the first and third letters are G. With a C_u of 15.0 and a C_c of 0.65, the criteria on the Classification chart for a well graded gravel has only been met by the C_u. Thus the soil is poorly graded and the second letter is P. Since the soil is non-plastic, the fourth letter is an M for silt. Final classification symbol = GP-GM.

#5 24% sand when subtracted from the total 100% leaves 76%fines. With a LL of 65, the soil falls into the equal to or greater than 50% LL column. When plotting the LL of 56% and PI of 26 on the Plasticity Chart this falls on the silt side of the A-Line. Hence the first letter is M. Since the LL is greater than 50%, the silt is highly compressible. Second letter = H. Final classification symbol = MH.

#6 63% gravel and 13% sand when subtracted from the 100% leaves a total of 24% fines. The soil falls on the Classification Procedure Chart into the more than 12%, equal to and less than 50% fines column. The 63% gravel gives the first letter of G. Since the soil is non-plastic, the second letter is M. Final Classification symbol = GM.

#7 25% gravel and 37% sand leaves a total of 38% fines. The percentage of fines places the soil in the more than 12%, equal to or less than 50% column of the Classification Prodecure Chart. With 37% sand the first letter is an S. When plotting the LL of 45% and the PI of 9 on the Plasticity Chart it falls into the silt range. The second letter is M. Final classification symbol = SM.

#8 0% gravel, 18% sand and 82% fines. The soil is gine grained because it has more than 50% fines. With a LL of 80%, it falls in the high compressibility column on the Classification Procedure Chart. Plotting the LL of 80% and the PI of 30, it falls in the silt range. Since the soil has organic material present, present, it would be classified as organic soil with the first letter being O. The second letter is H. Final classification symbol = symbol = CH.

#9 9% gravel, 23% sand and 68% fines. The soil is again fine grained, having more than 50% fines. The LL of 55% locates the soil on the Classification Procedure Chart in the equal to or greater than 50% LL Column (highly compressible). Plotting the LL of 55% and PI of 32, the point lies above the A-Line. Therefore, the first letter is C. Highly compressible soil makes the second letter an H. Final classification symbol = CH.

#10 61% gravel, 35% sand and 4% fines. Since the gravel is predominant the first letter is G. The soil is in the less than 5% fines column of the Classification Procedure Chart. Gradation characteristics indicate a well graded soil--Cc = 1.80 and Cu = 47. The second letter is W. Final classification symbol = GW.

#11 16% gravel, 9% sand and 75% fines. The LL of 85% places the soil in the equal to or greater tha the 50%LL columr. The LL of 85% and the PI of 40 classifies the soil as organic or silt but since it is non-plastic and non-organic, the first letter is an M. Since the LL is greater than 50%, the second letter is H. Final classification symbol= MH.

#12 39% gravel, 48% sand and 13% fines. The percentage of fines places the soil in the more than 12% equal to or less than 50% fines column. With 48% sand, the first letter is S. Plotting the LL of 20% and PI of 3 the soil falls into the silt range on the Plasticity Chart. The second letter is M. Final classification symbol = SM.

#13 15% gravel, 65% sand and 20% fines. The percentage of fines places the soil in the more than 12%, equal to or less than 50% fines column. With 65% sand the first letter is S. Plotting the LL of 50% and PI of 12, the soil falls in the silt range on the Plasticity Chart. The second letter is M. Final classification symbol = SM.

#14 13% gravel, 21% sand and 66% fines. Since it has more than 50% fines the soil is fine grained. With a LL of 42 it falls in the less than 50LL column on the Classification Procedure Chart. Since it is an organic soil the firstletter is O. With a LL of 42 it is low compressible. Second letter is L. Final classification = OL.

#15 39% gravel, 29% sand and 32% fines. The soil falls in the range of more than 12% equal to or less than 50% fines column on the Classification Procedure Chart, with 39% gravel the first letter is G. Plotting the LL of 60 and PI of 42 the soil falls in the clay range on the Plasticity Chart. Second letter is C. Final classification symbol = GC.

#16 11% gravel, 82% sand and 7% fines. With the high percentage of sand the first letter is S.. The percentage of fines places the soil in the range between 5% equal to and less than 12% fines column on the Classification Procedure Chart. (dual letter symbol). Uniformly or poorly graded since C_c is greater than 3. The second letter is P. Third letter is the same as the first. Since the soil is non-plastic the fourth letter is M. Final classification = SP-SM.

#17 50% gravel and 25% sand leaves 25% fines. Since fines are less than 50%, gravel gives the primary symbol of G. LL of 25 - PL of 19 = PI of 6. Plotting LL vs PI, the fines fall in the CL-ML range. In the fines $>12\% \leq 50\%$ range, four letters are required, hence final classification symbol: GC-GM.

#18 10% gravel and 39% sand leaves 51% fines. The soil is fine grained, having more than 50% fines. With a LL of 50%, it falls in the greater than or equal to 50% LL column. Plotting the LL of 50% and the PI of 20, it falls in the silt range. Since the soil has organic material present it would be classified as an organic soil with the first letter being O. The second letter is H. Final classification symbol = OH.

#19 27% gravel and 19% sand leaves 54% fines. With more than 50% fines. the soil is gine grained. With a LL of 24%, it falls in the low compressibility column on the classification procedure chart. Subtracting the PL of 19% from the LL of 24% leaves a PI of 5. Plotting the LL of 24% and the PI of 5, the fines fall in the CL-ML range. Final classification symbol = CL-ML.

#20 42% sand and 3% gritty fines when added together and subtracted from 100% leaves 55% gravel. A nearly vertical gradation curve indicates a poorly graded gravel. Final classification symbol = GP.

#21 42% sand and 4% cohesionless fines when added together and subtracted from 100% leaves 54% gravel. Gravel is uniformly graded. Final classification symbol = GP.

#22 39% gravel and 12% cohesive fines leaves a total of 49% sand. Soil falls in the range between 5% and equal to or less than 12% fines column on the Classification Procedure Chart requiring a dual letter symbol. With 49% sand, the first and third letters are S. Since the gradation curve is horizontal between the no. 40 and no. 80 sieves the soil is poorly graded. Hence, the second letter is P. Since the fines are cohesive, the fourth letter is C. Final classivication symbol SP-SC.

SOIL MOISTURE CONTENT

PROJECT	DATE
V/STOL AIRFIELD	26 Mar 81

EXCAVATION NUMBER	SAMPLE NUMBER	FORMULA
(Bore Samples)	1-1, 1-2, 2-1, 2-2, 3-1, 3-2	Water Content, $w = \frac{W_w}{W_s} \times 100$

TEST						
RUN NUMBER						
TARE NUMBER	1-1	1-2	2-1	2-2	3-1	3-2
A. WEIGHT OF TARE + WET SOIL	1-1	1-2	2-1	2-2	3-1	3-2
B. WEIGHT OF TARE + DRY SOIL	18.70	19.20	44.30	47.80	26.20	53.30
C. WEIGHT OF WATER, W_W (A. - B.)	18.63	19.12	41.97	44.46	25.03	48.71
D. WEIGHT OF TARE	0.07	0.08	2.33	3.34	1.17	4.59
E. WEIGHT OF DRY SOIL, W_S (B. - D.)	15.67	16.14	16.09	18.45	15.81	15.95
WATER CONTENT, w	2.96	2.98	25.88	26.01	9.22	32.76
TEST	2.36 %	2.68 %	9.00 %	12.84 %	12.69 %	14.01 %
RUN NUMBER						
TARE NUMBER	4-1	4-2				
A. WEIGHT OF TARE + WET SOIL	4-1	4-2				
B. WEIGHT OF TARE + DRY SOIL	98.60	99.30				
C. WEIGHT OF WATER, W_W (A. - B.)	91.70	91.70				
D. WEIGHT OF TARE	6.90	7.60				
E. WEIGHT OF DRY SOIL, W_S (B. - D.)	51.20	47.20				
WATER CONTENT, w	40.50	44.50				
TEST	17.04 %	17.08 %	%	%	%	%
RUN NUMBER						
TARE NUMBER						
A. WEIGHT OF TARE + WET SOIL						
B. WEIGHT OF TARE + DRY SOIL						
C. WEIGHT OF WATER, W_W (A. - B.)						
D. WEIGHT OF TARE						
E. WEIGHT OF DRY SOIL, W_S (B. - D.)						
WATER CONTENT, w						
TEST	%	%	%	%	%	%
RUN NUMBER						
TARE NUMBER						
A. WEIGHT OF TARE + WET SOIL						
B. WEIGHT OF TARE + DRY SOIL						
C. WEIGHT OF WATER, W_W (A. - B.)						
D. WEIGHT OF TARE						
E. WEIGHT OF DRY SOIL, W_S (B. - D.)						
WATER CONTENT, w						
TEST	%	%	%	%	%	%
RUN NUMBER						
TARE NUMBER						
A. WEIGHT OF TARE + WET SOIL						
B. WEIGHT OF TARE + DRY SOIL						
C. WEIGHT OF WATER, W_W (A. - B.)						
D. WEIGHT OF TARE						
E. WEIGHT OF DRY SOIL, W_S (B. - D.)						
WATER CONTENT, w						
TEST	%	%	%	%	%	%

REMARKS (Continue on reverse if additional space is required)

TECHNICIAN (Signature)	COMPUTED BY (Signature)	CHECKED BY (Signature)

DD FORM 1 FEB 62 1205 EDITION OF 1 AUG 57 IS OBSOLETE.

FIELD IDENTIFICATION

#1 Greater than 50% fines, fine grained
Non-organic
Cannot roll thread, M
Positive reaction to shaking test, M
Ribbon 2", M
CLASSIFICATION SYMBOL IS M

#2 30% gravel
$\frac{60}{100}$ x 70 = 42% sand

100 - (30+42) = 28% fines
Shines, C
Wet shaking, M
Bite, C
CLASSIFICATION SYMBOL IS SC

#3 45% gravel
$\frac{60}{100}$ x 55 = 33% sand

100 - (45+33) = 22% fines
Dry strength, M
Feel test, M
Thread test, M
CLASSIFICATION SYMBOL IS GM

#4 10% gravel
15% sand
75% fines
Dry strength, CH
Ribbon, CH
CLASSIFICATION SYMBOL IS CH

#5a 45% gravel
$\frac{95}{100}$ x 55 = 52.25 sand

100 - (45+52.25) = 2.75% fines
Shine test, C
Wet shaking, C
Ribbon, CL
Thread test, CL
Bite test, M
CLASSIFICATION SYMBOL IS S

#5b 40% gravel

$\frac{80}{100}$ x 60 = 48% sand

100 - (40+48) = 12% fines
Non-organic
Dry strength, CH
Powder test, C
Feel test, C
Bite test, M
CLASSIFICATION SYMBOL IS SC

Best selection S Why?

Value as sub-base, fair to poor
Low frost susceptibility
Almost no volume change
Much higher CBR value
Excellent drainage

☆ U.S. Government Printing Office: 1985—491-036/45719